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DESCRIPTION

DEVICE-INCORPORATED SUBSTRATE AND METHOD OF MANUFACTURING THEREOF AS WELL AS PRINTED CIRCUIT BOARD AND METHOD OF MANUFACTURING THEREOF

TECHNICAL FIELD

The present invention relates to a device-incorporated substrate and a method of manufacturing a device-incorporated substrate, as well as to a printed circuit board and a method of manufacturing a printed circuit board in which the formation of a conductor pattern is performed through a transfer method using a transfer sheet. More specifically, the present invention relates to a device-incorporated substrate and a method of manufacturing a device-incorporated substrate, as well as to a printed circuit board and a method of manufacturing a printed circuit board that are superior in terms of dimensional stability and through which a fine-pitch conductor pattern can be formed.

BACKGROUND ART

In recent years, with the increasing reduction in size and the advance in functionality of electronic devices, such as mobile phones, PDAs (Personal Digital Assistants), laptop PCs and the like, high-density packaging of electronic components used in them is becoming essential. Conventionally, high-density packaging of electronic components has been achieved by making component terminals more fine-pitched as a result of making electronic components smaller, by making the conductor pattern on a printed circuit board on which electronic components are mounted finer, and so forth.

In addition, in recent years, the development of multi-layer printed circuit boards which make three-dimensional wiring possible by layering printed circuit boards is being advanced, and further, the development of device-incorporated substrates that aim to further improve packaging efficiency by having electronic components, such as chip resistors, chip capacitors and the like, and electric devices, such as semiconductor chips and the like, built into these multilayer printed circuit boards is also being advanced.

As a method of forming a conductor pattern for a printed circuit board, a transfer method using a transfer sheet is conventionally known. The process of manufacturing a printed circuit board using this transfer method includes, mainly, a pattern formation step for forming a conductor pattern on one surface of a transfer sheet, and a pattern transfer step for removing the transfer sheet after the transfer sheet has been adhered to an insulation layer with the formed conductor pattern in between.

A printed circuit board produced through a transfer method can be easily multi-layered by forming, in desired places of the insulation layer, via-holes for connecting the layers.

As conventional art of this sort, for example in Japanese Patent No. 3051700, a method of manufacturing a device-incorporated substrate using a transfer method is disclosed. Hereinafter, a conventional method of manufacturing a device-incorporated substrate will be described with reference to Fig. 13A through Fig. 13F.

Fig. 13A through Fig. 13F are stepwise sectional views showing a conventional method of manufacturing a device-incorporated substrate. A void section 32 for housing a semiconductor chip 36 and via-hole conductors 33 for connecting

layers and which are made by filling through-holes with a conductive paste are each formed in an insulating base material 31 (Fig. 13A). On the other hand, on one side of a transfer sheet 34 is formed a conductor pattern 35 to be transferred onto the insulating base material 31 (Fig. 13B).

Here, the insulating base material 31 is comprised of a thermo-setting resin that is partially cured, and the transfer sheet 34 is comprised of a resin film of polyethylene terephthalate (PET) or the like. In addition, the conductor pattern 35 is formed by performing pattern etching on a conductor foil, such as a copper foil or the like, that is adhered to the transfer sheet 34 in advance.

Next, the semiconductor chip 36 is bonded to a predetermined position of the conductor pattern 35 formed on the transfer sheet 34 (Fig. 13C). Then, the upper surface of the insulating base material 31 and the side of the transfer sheet 34 on which there is the conductor pattern 35 are pressure bonded and the semiconductor chip 36 is housed inside the void section 32, while the conductor pattern 35 is connected with the via-hole conductors 33 (Fig. 13D). The conductor pattern is buried in the upper surface of the partially cured insulating base material 31, and thereafter, just the transfer sheet 34 is removed from the insulating base material 31. Then, by completely curing the base material 31 through a heat treatment, a device-incorporated substrate 30 is obtained (Fig. 13E).

In addition, as shown in Fig. 13F, by layering insulating base materials 39 and 40 on which conductor patterns 37 and 38, respectively, are formed through a method similar to the one above onto the above-mentioned device-incorporated substrate 30, a multi-layered printed circuit board 41 is obtained.

However, in this conventional method of manufacturing a device-incorporated substrate, because the transfer sheet 34 is comprised chiefly of a resin film, there is a problem in that due to stretching and warpage in the transfer sheet 34 caused during handling, errors in the pattern configuration of the conductor pattern 35 to be transferred occur with greater likelihood. Therefore, with this conventional method of manufacturing a device-incorporated substrate, it is extremely difficult to accommodate the trend towards finer (more fine-pitched) conductor patterns, which is to progress further in the future.

In addition, the conductor pattern 35 formed on the transfer sheet 34 is formed, as disclosed in Japanese Patent Application Publication No. HEI 9-270578 for example, by pattern etching a metal foil adhered onto the transfer sheet 34, or, as disclosed in Japanese Patent Application Publication No. HEI 10-335787 for example, by pattern etching a metal layer that is formed on the transfer sheet 34 directly through sputtering or the like. As the method of etching, wet etching is adopted.

In other words, in the conventional method of manufacturing a device-incorporated substrate, because wet etching is used in the formation of the conductor pattern 35, there is a problem which is that, in the future, it is going to become difficult to form fine-pitch patterns with high precision.

On the other hand, it is also conceivable to have the transfer sheet be made of a metal material such as stainless steel or the like. In this case, because the rigidity is higher as compared to a case where the transfer sheet is made of a resin film, the dimensional stability of the conductor pattern is improved. However, in this case, there is a problem in that if the rigidity of the insulating base material, which is the transfer

target, is high, it becomes difficult to remove the transfer sheet from the insulating base material and the transfer operation for the conductor pattern cannot be performed properly.

The present invention is made in view of the problems above, and makes it an issue to provide a device-incorporated substrate and a method for manufacturing a device-incorporated substrate, as well as to a printed circuit board and a method of manufacturing a printed circuit board in which the dimensional stability of the conductor pattern is secured to make it possible to form a fine-pitch conductor pattern on an insulating layer with high precision and in which the removal of the transfer sheet can be performed properly.

DISCLOSURE OF THE INVENTION

In solving the issues above, in the present invention, by making the transfer sheet metallic and giving the transfer sheet electrical conductivity, forming a fine-pitch conductor pattern with high precision is made possible using a pattern plating technique by an additive method.

When transferring the formed conductor pattern to the insulating layer, the transfer sheet is removed from the insulating layer after the transfer sheet and the insulating layer have been adhered to each other. In the present invention, because the transfer sheet is comprised chiefly of a metal material, there is hardly any dimensional change during handling, and thus, the dimensional stability of the conductor pattern to be transferred is secured.

In addition, in the present invention, the removal of the transfer sheet from the insulating layer is done mainly by dissolving and removing the transfer sheet. Thus, even in cases where the insulating layer, which is the transfer target, has

strong rigidity, it is possible to ensure a proper transfer operation for the conductor pattern.

Here, the transfer sheet may be so configured to include a metal base material, and a dissolvee metal layer that is layered so as to be separable with respect to the metal base material and onto which a conductor pattern is formed. The metal base material accounts for the main portion of the entire thickness of the transfer sheet, and is so made that it has, mainly, mechanical properties or material properties which are essential at the time of handling. When such a metal base material is separated and removed from the dissolvee metal layer, the dissolvee metal layer, which is part of the transfer sheet, remains on the conductor pattern that has been transferred onto the insulating layer. As such, by dissolving and removing this dissolvee metal layer, of the transfer sheet is completely removed from the insulating layer. In such a case, since the time required for the dissolution and removal of the transfer sheet can be shortened, the removal process for the transfer sheet is simplified.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view that shows, schematically, the configuration of a device-incorporated substrate according to a first embodiment of the present invention;

Fig. 2 is a sectional view showing a state where the device-incorporated substrate shown in Fig. 1 has been multi-layered;

Figs. 3(A) through (H) are stepwise sectional views illustrating a method of manufacturing a device-incorporated substrate according to the first embodiment of the present invention, where (A) through (C) show a void section forming

step, (D) through (G) show a pattern forming step, and (H) shows part of a pattern transfer step;

Fig. 4A through Fig. 4D are stepwise sectional views illustrating a method of manufacturing a device-incorporated substrate according to the first embodiment of the present invention, where Fig. 4A shows a device housing step, and Fig. 4B through Fig. 4D show a step for removing a transfer sheet;

Fig. 5A is a sectional view that shows, schematically, the configuration of a transfer sheet applied in the first embodiment of the present invention, and Fig. 5B through Fig. 5D are sectional views illustrating modifications thereof;

Fig. 6 is a flow chart illustrating a method of manufacturing a device-incorporated substrate according to the first embodiment of the present invention;

Figs. 7(A) through (G) are stepwise sectional views illustrating a method of manufacturing a printed circuit board according to a second embodiment of the present invention, where, in particular, (C) through (F) show a pattern forming step, and (G) shows part of a pattern transfer step;

Fig. 8A through Fig. 8C are stepwise sectional views illustrating a method of manufacturing a printed circuit board according to the second embodiment of the present invention, and, in particular, show a removal process for a transfer sheet;

Figs. 9(A) through (H) are stepwise sectional views illustrating a method of manufacturing a device-incorporated substrate according to a third embodiment of the present invention;

Fig. 10A through Fig. 10D are stepwise sectional views illustrating a method of manufacturing a device-incorporated substrate according to the third embodiment of the present invention;

Fig. 11A through Fig. 11F are stepwise sectional views illustrating a method of manufacturing a device-incorporated substrate according to a fourth embodiment of the present invention;

Fig. 12 is a sectional view of a main portion illustrating a modification of a chip mounting step of the first embodiment of the present invention; and

Fig. 13A through Fig. 13F are stepwise sectional views illustrating a conventional method of manufacturing a device-incorporated substrate.

BEST MODES FOR CARRYING OUT THE INVENTION

Hereinafter, each embodiment of the present invention is described with reference to the drawings.

(First Embodiment)

Fig. 1 through Fig. 5D show the configuration of a device-incorporated substrate 50 according to the first embodiment of the present invention. An insulating base material 51, which constitutes an insulating layer, has formed therein a void section 52 for housing a semiconductor chip 56 as an electric device, and through-holes 53, 53 for connecting the front and back sides of the insulating base material 51. The through-holes 53, 53 are filled with an electrically conductive material 59, such as solder and the like.

In the present embodiment, the insulating base material is comprised of a resin base material of mainly a thermoplastic resin material, however, it is not limited thereto, and may be selected as deemed appropriate depending on the application or usage. For example, glass fiber impregnated with epoxy resin, glass fiber impregnated with polyimide resin, or paper impregnated with phenol resin or the like may be used. In

addition, bismaleimide triazine resin, benzo-cyclo-butene resin, liquid crystal polymers and the like may also be used.

For the electrically conductive material 59 that the through-holes 53 are filled with, either a leaded or non-leaded solder material may be used, but from an ecological point of view, it is preferable that a non-leaded solder material be used. As non-leaded solder materials, alloys of Sn-Ag to which Bi, In, Cu, Sb and the like are added are well known. In addition, as electrically conductive materials other than solder materials, an electrically conductive paste that is obtained by mixing electrically conductive particles, such as silver powder, copper powder and the like, in resin may be used, for example.

On the surface of the insulating base material 51, there is provided an electrically non-conductive adhesive 54, and a conductor pattern 55 that has been patterned to a predetermined configuration is adhered onto this adhesive 54. The conductor pattern 55 is comprised of, for example, an electroplated film of copper, and is electrically bonded to the semiconductor chip 56 housed within the void section 52, while it is also electrically connected with the electrically conductive material 59 inside the through-holes 53. In the present invention, as will be described later, the conductor pattern 55 is formed on the insulating base material 51 by a transfer method.

The semiconductor chip 56 in the present embodiment is comprised of a bare chip, and gold or gold plated bumps (metal protrusive electrodes) 57 are formed on an aluminum electrode pad section provided on its bonding surface (active surface). In addition, the bumps 57 may be, besides the ball bumps shown in the drawing, stud bumps or plated bumps. Further, instead of semiconductor bare chips, semiconductor packaging components, such as BGA/CSP and the like, in which bumps are formed in

rows or within a given area may also be used for the present invention.

Inside the void section 52 and between the conductor pattern 55 and the semiconductor chip 56 is formed an underfill resin layer 58 comprised of thermosetting adhesive resin, such as epoxy resin and the like, for example. The semiconductor chip 56 maintains its bond with the conductor pattern 55 by virtue of the underfill resin layer 58. In addition, the semiconductor chip 56 within the void section 52 may also be completely sealed with the same resin material.

The surface side of the conductor pattern 55 is covered with a solder resist 60, but openings 60a, 60a are formed in places corresponding to the through-holes 53, and thus the conductor pattern 55 is exposed.

According to the device-incorporated substrate 50 of the present embodiment, since the conductor pattern 55 is comprised of an electroplated layer, it becomes possible to make the conductor pattern 55 finer pitched, and thus, it is possible to achieve a further improvement in packaging density.

Next, Fig. 2 shows a device-incorporated multi-layer substrate 65 in which a plurality of the device-incorporated substrates 50 configured in the manner described above are layered. In the present example, a configuration where three of the device-incorporated substrates 50 of the configuration described above are mounted on a base substrate 66 is shown. The electrical and mechanical connections between the layers in the device-incorporated multi-layer substrate 65 is achieved through the electrically conductive material 59 that is bonded to the surface of the conductor pattern 55 via the openings 60a in the solder resist 60.

In addition, by connecting the layers with the electrically conductive material 59 as mentioned above, connections can be made in a shorter time and resistance can be kept lower as compared to a case where an electrically conductive paste is used.

The base substrate 66 has an insulating base material 67, an upper wiring layer 70 and a lower wiring layer 71 pattern-formed on the front and back surfaces of the insulating base material 67, and through-hole plating 68 for connecting these wiring layers 70 and 71 formed. In addition, the insides of these through-holes are filled with a filler 69 of either an electrically conductive material or an electrically non-conductive material, and thus, the so-called pop-corn phenomenon is prevented and heat dissipation efficiency is improved.

The device-incorporated multi-layer substrate 65 thus configured takes on the configuration of a land grid array (LGA), and when being mounted on a mother board, external electrodes, such as ball bumps and the like, are provided on the lower wiring layer 71 that is exposed via openings 73a, 73a in a solder resist 73. In addition, some other electric device or electric component may further be mounted on the wiring layer (conductor pattern) 55 of the device-incorporated substrate 50 at the top-most layer.

Next, a method of manufacturing the device-incorporated substrate 50 related to the present invention will be described with reference to Fig. 3 through Fig. 6.

First, as shown in Fig. 3(A), the insulating base material 51 of the configuration described above is prepared, and the adhesive 54 for forming an adhesive material layer is applied onto the surface thereof (Fig. 3(B)).

The adhesive 54 is there to adhere the conductor pattern 55, which is later transferred, to the insulating base material 51,

and it is necessary that it be electrically non-conductive. In addition, in order to prevent the adhesive from flowing out into the void section 52 and the through-holes 53 when the conductor pattern 55 is transferred, a material that has low flow and has high shape holding properties is used for the adhesive 54. An example of such a material would include, for example, "AS-3000" produced by Hitachi Chemical Co., Ltd.

Next, as shown in Fig. 3(C), a void section forming step (step S1) for forming the void section 52 for housing a device and the through-holes 53 for connecting layers is carried out with respect to the insulating base material 51. For example, known drilling processing techniques such as processes using drills and routers, mold punching, laser processing and the like may be adopted for the forming of the void section 52 and through-holes 53, and a plurality of sheets may be processed at once. In addition, internal dimensions greater than the outer dimensions of the semiconductor chip 56 to be housed is required for the void section 52.

Along with the preparation step for the insulating base material 51 described above, a step of forming the conductor pattern 55 (step S2) is carried out as shown in Figs. 3(D) through (G). In the present embodiment, in forming the conductor pattern 55, a transfer sheet 61 of the configuration shown in Fig. 5A is used.

The transfer sheet 61 has a three-layer structure of a metal base material 62 of copper of a thickness of, for example, approximately 100 μm, an electrically conductive adhesive resin layer 63, and a dissolvee metal layer 64 of chromium (Cr) of a thickness of, for example, 5 μm or less. The metal base material 62 and the dissolvee metal layer 64 are layered so as to be

mutually separable with the electrically conductive adhesive resin layer 63 in between.

The metal base material 62 accounts for the main portion of the entire thickness of the transfer sheet 61, and is so made that it has, mainly, mechanical properties or material properties which are essential for handling. The electrically conductive adhesive resin layer 63 is comprised of a material that is able to ensure conduction between the metal base material 62 and the dissolvee metal layer 64, and that enables both to be separated and removed. For example, benzotriazole resin that is formed in a layer is used. The dissolvee metal layer 64 is comprised of a metal foil or a metal plating layer, and is made of a metal material that is dissimilar from the conductor pattern 55 so that it can be selectively etched with respect to the conductor pattern 55.

In addition, configuration examples for separating and removing both the metal base material 62 and the dissolvee metal layer 64 are not limited to those above, and other configuration examples may also be adopted, details of which will be described later.

Referring to Fig. 3(D), on the surface on the side of the dissolvee metal layer 64 of the transfer sheet 61 of the configuration mentioned above, a photoresist film 72 is formed. The photoresist film 72 may be either of a dry film resist and a liquid resist. Then, the photoresist film 72 is patterned to a predetermined configuration by performing various processes such as exposure and development on the formed photoresist film 72, thereby forming a plating resist 72A (Fig. 3(E)).

Subsequently, the transfer sheet 61 is immersed into, for example, an electrolytic bath of copper along with the plating resist 72A and is connected to a cathode electrode not shown in

the drawing, thereby depositing an electroplated layer 55A upon the dissolvee metal layer 64 (Fig. 3(F)). Then, after the electroplated layer 55A is formed, the plating resist 72A is removed (Fig. 3(G)). Thus, the conductor pattern 55 comprised of the electroplated layer 55A is formed on the surface of the transfer sheet 61.

In addition, the electroplated layer 55A is formed not only on the dissolvee metal layer 64 of the transfer sheet 61 but also on the metal base material 62, however, illustration thereof has been omitted.

In general, compared to a method of forming a conductor pattern by removing unwanted parts of a conductor layer through wet etching (a subtractive method), a method of forming a conductor pattern by depositing a conductor layer only in desired places through electroplating (an additive method) allows for the formation of finer patterns. Therefore, according to the present embodiment, fine-pitch conductor patterns with an L/S of, for example, 10 μm/10 μm can be formed with high precision.

In addition, in cases where fine-pitch conductor patterns are not required, a conductor pattern may also be formed by further forming a conductor layer, by such methods as electroplating and the like, on the dissolvee metal layer 64, and pattern etching this conductor layer.

Next, as shown in Fig. 3(H), the transfer sheet 61 and the insulating base material 51 are adhered to each other with the formed conductor pattern 55 in between, and the conductor pattern 55 is adhered to the adhesive 54 on the insulating base material 51 (step S3).

Here, because the transfer sheet 61 is metallic, it has higher strength as compared to a conventional transfer sheet

made of a resin film, and therefore, stretching and warpage during handling of the transfer sheet 61 are suppressed, and it is possible to adhere the fine-pitch conductor pattern 55 properly onto the insulating base material 51 with high dimensional stability.

In addition, because the transfer sheet 61 can be given sufficient strength, pattern transfer at higher loads than are conventional becomes possible, and limitations on the transfer process can be reduced. In particular, because local deformations in the transfer sheet upon transfer are suppressed, deformation and breaks in the conductor pattern can be prevented.

Subsequently, as shown in Fig. 4A, a step of housing the semiconductor chip 56 within the void section 52 of the insulating base material 51, and of bonding the bumps 57 formed on the active surface of the semiconductor chip 56 to the conductor pattern 55 is performed (step S4). The mounting of the semiconductor chip 56 with respect to the conductor pattern 55 is performed using, for example, a known mounter apparatus.

In addition, in the present embodiment, since the bumps 57 are formed with gold or with gold plating on their surfaces, if they are bonded directly to the conductor pattern (copper) 55, it becomes a bond between Au-Cu. As such, by further forming a tin (Sn) metal film, through electroplating and the like, on the surface of the conductor pattern 55 formed on the transfer sheet 61, the bonding step mentioned above results in a bond between Au-Sn, and therefore, as compared to a bond between Au-Cu, bonding of the semiconductor chip 56 at lower temperatures and lower loads becomes possible. Sn metals would include Sn and Sn alloys (SnAg, SnBi, SnCu and the like). In addition, besides

Sn metals, similar results can also be achieved by forming a NiP/Au film.

On the other hand, instead of forming the bumps 57 of the semiconductor chip 56 with Au, they may be formed with a Sn metal. In such a case, the bumps may be formed solely of a Sn metal, or they may be balls of other metals or resin balls whose surface is plated with a Sn metal. Sn metals would include Sn, SnAg, SnBi, SnCu, SnAgCu, SnAgBi, SnAgBiCu, and the like.

After the semiconductor chip is bonded to the conductor pattern 55, a step of injecting thermosetting resin, such as epoxy, into the void section 52, and forming the underfill resin layer 58 between the conductor pattern 55 and the semiconductor chip 56 is performed (Fig. 4A, step S5). Thus, the conductor pattern 55 is supported by both the transfer sheet 61 and the underfill resin layer 58.

Thus, a “device housing step” related to the present invention is comprised of a step of bonding the semiconductor chip 56 to the conductor pattern 55 and a step of forming the underfill resin layer 58 for sealing the bonded semiconductor chip 56 within the void section 52.

In addition, the step of bonding the semiconductor chip 56 is not limited to the one mentioned above, and the semiconductor chip 56 may be bonded to the conductor pattern 55 on the transfer sheet 61 in advance, and the bonded semiconductor chip 56 may be housed inside the void section 52 when the insulating base material 51 and the transfer sheet 61 are adhered to each other. In this case, since the transfer sheet 61 is metallic, deformation and the like of the transfer sheet 61 due to the weight of the semiconductor chip 56 itself can be suppressed.

Here, if a substance having adhesive properties is used for the plating resist 72A, it is possible to use the plating resist 72A

as an underfill resin layer for the semiconductor chip 56 as shown in Fig. 12, for example. In this case, the thickness of the conductor pattern 55 need only be made a length that can be reached by the bumps 57 of the semiconductor chip 56.

Next, a step of removing the transfer sheet 61 is performed. In the present embodiment, the removal of the transfer sheet 61 is comprised of a step of separating and removing the metal base material 62 from the dissolvee metal layer 64 (Fig. 4B) and a step of dissolving and removing the dissolvee metal layer 64 (Fig. 4C).

Referring to Fig. 4B, the step of separating and removing the metal base material 62 from the dissolvee metal layer 64 is performed by separating the metal base material 62 from the dissolvee metal layer 64 via the electrically conductive adhesive resin layer 63 (step S6).

In addition, in order to have it separate from the dissolvee metal layer 64 along with the metal base material 62, the electrically conductive adhesive resin layer 63 may have a release agent applied in advance on a predetermined area of its surface on the side of the dissolvee metal layer 64.

By adding, at the boundary section between the metal base material 62 and the dissolvee metal layer 64 at the edge of the transfer sheet 61, a slit for starting separation, the separation process for the metal base material 62 can be performed with ease. In addition, during the process of separating the metal base material 62, since the dissolvee metal layer 64 is supported by the adhesive 54 and the underfill resin layer 58 via the conductor pattern 55, it is possible to perform the separation and removal of the metal base material 62 and the dissolvee metal layer 64 properly (Fig. 4C).

On the other hand, in the step of dissolving and removing the dissolvee metal layer 64, only the dissolvee metal layer 64 is selectively removed (Fig. 4D, step S7) using an etching solution that dissolves the dissolvee metal layer 64 but not the conductor pattern 55. In the present embodiment, since the conductor pattern 55 is formed with copper and the dissolvee metal layer 64 with chromium, by using, for example, a hydrochloric etching solution, just the dissolvee metal layer 64 can be dissolved and removed while leaving the conductor pattern 55.

Thus, a "pattern transfer step" in the present embodiment is comprised of the respective steps from the step of adhering the insulating base material 51 and the transfer sheet 61 to each other (step S3) to the step of dissolving and removing the dissolvee metal layer 64 (step S7).

After the removal of the transfer sheet 61 is completed, an electrical conductor filling step of filling the through-holes 53 of the insulating base material 51 with the electrically conductive material 59 as an electrically conductive material through screen printing or a dispensing method is performed as shown in Fig. 1, while a step of covering the surface of the conductor pattern 55 with the solder resist 60 except for parts corresponding to areas where the through-holes 53 are formed is performed (step S8). In addition, if the device-incorporated multi-layer substrate 65 shown in Fig. 2 is to be obtained, a predetermined multi-layering process is performed (step S9).

Thus, the device-incorporated substrate 50 of the present embodiment is produced.

According to the present embodiment, since the transfer sheet 61 is made metallic, it is possible to form the fine-pitch conductor pattern 55 with high precision using a pattern plating technique based on an electroplating method. In addition, since

the transfer sheet 61 has predetermined mechanical strength and heat resistance, dimensional changes during handling or heating is virtually eliminated, and it is possible to ensure the dimensional stability of the conductor pattern 55 that is transferred.

Further, because the removal of the transfer sheet 61 in the pattern transfer step is ultimately performed by way of dissolving through etching, even in cases where the rigidity of the insulating base material 51 is strong, it is possible to ensure an adequate operation of transferring the conductor pattern 55.

In addition, according to the present embodiment, since the transfer sheet 61 is so configured to include the metal base material 62 and the dissolvee metal layer 64 that is layered so as to be separable with respect to this metal base material 62, and since the removal of the transfer sheet 61 is comprised of a step of separating and removing the metal base material 62 from the dissolvee metal layer 64 and a step of dissolving and removing the dissolvee metal layer 64, the removal of the transfer sheet 61 is made easier, and thus, an improvement in productivity can be expected.

(Second Embodiment)

Fig. 7, and Fig. 8A through Fig. 8C show the second embodiment of the present invention. In the present embodiment, a method of manufacturing a printed circuit board related to the present invention will be described.

First, as shown in Fig. 7(A), an insulating base material 81 is prepared, and an adhesive 84 for forming an adhesive material layer is applied onto the surface thereof (Fig. 7(B)). The same materials as those of the insulating base material 51 and the adhesive 54 described in the first embodiment above are

used for the insulating base material 81 and the adhesive 84 of the present embodiment.

On the other hand, a conductor pattern 85 to be transferred onto the insulating base material 81 is, as in the first embodiment, formed on a metallic transfer sheet 91 through electroplating as shown in Figs. 7(C) through (F). The transfer sheet 91 has, though not described in detail, a configuration similar to that of the transfer sheet 61 in the first embodiment, and is comprised of a metal base material 92 of copper, a dissolvee metal layer 94 of chromium, and an electrically conductive adhesive resin layer (illustration omitted) that lies between the two.

On the dissolvee metal layer 94 of the transfer sheet 91 is formed a plating resist 73A which is obtained by patterning a solder resist 73, and the conductor pattern 85 is comprised of an electroplated layer (copper) 85A that is deposited in areas marked out by the plating resist 73A (Fig. 7(E)). By adhering the transfer sheet 91 on which the conductor pattern 85 is formed onto the insulating base material 81 after the plating resist 73A has been removed, the conductor pattern 85 is transferred onto the adhesive 84 (Fig. 7(G)).

Subsequently, as shown in Fig. 8A through Fig. 8C, a step of removing the transfer sheet 91 that has been adhered onto the insulating base material 81 is performed. The removal of the transfer sheet 91, as in the first embodiment, is performed through a step of separating and removing the metal base material 92 from the dissolvee metal layer 94, and a step of dissolving and removing the dissolvee metal layer 94. In particular, for the dissolution and removal of the dissolvee metal layer 94, a hydrochloric etchant, for example, that dissolves the

dissolvee metal layer (Cr) 94 but not the conductor pattern (Cu) 85 may be used.

A printed circuit board 80 thus produced takes on, as shown in Fig. 8C, a configuration where the conductor pattern 85 formed through electroplating is adhered to the adhesive 84 on the insulating base material 81.

According to the present embodiment, because the transfer sheet 91 is made metallic, it is possible to form the fine-pitch conductor pattern 85 with high precision using a pattern plating technique based on electroplating. In addition, since the transfer sheet 91 has predetermined mechanical strength and heat resistance, dimensional change during handling and heating can be virtually eliminated, thereby ensuring the dimensional stability of the conductor pattern 85 that is transferred.

Further, because the removal of the transfer sheet 91 in the pattern transfer step is ultimately carried out by dissolution through etching, a proper transfer process of the conductor pattern 85 can be ensured even in cases where the rigidity of the insulating base material 81 is strong.

In addition, according to the present embodiment, since the transfer sheet 91 is made to include the metal base material 92 and the dissolvee metal layer 94 that is layered so as to be separable with respect to this metal base material 92, and since the removal of the transfer sheet 91 is comprised of a step of separating and removing the metal base material 92 from the dissolvee metal layer 94, and a step of dissolving and removing the dissolvee metal layer 94, the removal of the transfer sheet 91 becomes easier, and thus, an improvement in productivity can be expected.

(Third Embodiment)

Fig. 9, and Fig. 10A through Fig. 10D show the third embodiment of the present invention. In the present embodiment, a method of manufacturing a device-incorporated substrate related to the present invention will be described. It is to be noted that, in the drawings, the same reference numerals are given to parts that have correspondence in the first embodiment described above, and detailed descriptions thereof will be omitted.

First, as shown in Fig. 9(A), an insulating base material 51 is prepared, and an adhesive for forming an adhesive 54 is applied onto the surface thereof (Fig. 9(B)).

Subsequently, as shown in Fig. 9(C), a void section forming step for forming a void section 52 for housing a device and through-holes 53 for connecting layers is performed with respect to the insulating base material 51.

In conjunction with the preparation step for the insulating base material 51, a step of forming a conductor pattern 55 is performed as shown in Figs. 9(D) through (G).

In the present embodiment, in forming the conductor pattern 55, a transfer sheet 61 of the configuration shown in Fig. 5A is used. In other words, it is comprised of a metal base material 62 of copper, a dissolvee metal layer 64 of chromium, and an electrically conductive adhesive resin layer that lies between the two (Fig. 9(D)).

The conductor pattern 55 shown in Fig. 9(E) is, as in the first embodiment described above, comprised of an electroplated layer formed on the surface of the transfer sheet 61 on the side of the dissolvee metal layer 64.

In the present embodiment, a step of burying an insulating film in the gaps in the formed conductor pattern, and

of flattening the surface of the transfer sheet 61 on the side of the dissolvee metal layer 64 is then performed.

In this step, first, as shown in Fig. 9(F), an insulating film 87 of an insulating resin such as epoxy resin, for example, is applied onto the entire surface of the transfer sheet 61 on the side of the dissolvee metal layer 64 from above the formed conductor pattern 55 through a screen printing method, and is then cured.

Then, as shown in Fig. 9(G), the cured insulating film 87 is buffed, and the surface of conductor pattern 55 is exposed.

Thus, the insulating film 87 is buried into the gaps of the conductor pattern 55, and the surface of the transfer sheet 61 on the side of the dissolvee metal layer 64 is flattened.

Subsequently, as shown in Fig. 9(H), the transfer sheet 61 and the insulating base material 51 are adhered to each other with the formed conductor pattern 55 in between, thereby adhering the conductor pattern 55 onto the adhesive 54 on the insulating base material 51.

Here, because the transfer sheet 61 is metallic, its strength is higher as compared to a conventional transfer sheet that is comprised of a resin film, and therefore, it is possible to suppress stretching and warpage of the transfer sheet 61 during handling, and to adhere the fine-pitch conductor pattern 55 properly onto the insulating base material 51 with high dimensional stability.

In addition, because sufficient strength can be given to the transfer sheet 61, pattern transferring at higher loads than is conventional becomes possible, and limitations on the transfer process can be reduced. In particular, because local deformations in the transfer sheet upon transfer are suppressed,

deformation and breaks in the conductor pattern can be prevented.

Further, because the surface of the transfer sheet 61 on the side of the dissolvee metal layer 64 is flattened by having the insulating film 87 buried in the gaps in the conductor pattern 55, adhesion with the adhesive 54 on the insulating base material 51 can be made stronger, thereby enhancing adhesive strength.

Subsequently, as shown in Fig. 10A, a step of housing a semiconductor chip 56 inside the void section 52 of the insulating base material 51, and of bonding bumps 57 formed on the active surface thereof to the conductor pattern 55 is performed.

After the semiconductor chip 56 is bonded to the conductor pattern 55, epoxy resin, for example, is injected into the void section 52, thereby forming an underfill resin layer 58 between the conductor pattern 55 and the semiconductor chip 56. Thus, the conductor pattern 55 is supported by both the transfer sheet 61 and the underfill resin layer 58.

In addition, since the bumps of the semiconductor chip 56 are formed with gold or with gold plating on their surfaces, by forming a metal plating of a Sn metal or a Ni/Au metal on the surface of the conductor pattern 55 of copper, chip mounting under low temperature and low load environments may be realized.

In this case, in the present embodiment, since the insulating film 87 is buried between the conductor pattern 55 and the conductor pattern 55, a bridge phenomenon across the pattern due to isotropic growth of the metal plating can be prevented.

In addition, by soft-etching the area corresponding to the chip connection land on the conductor pattern 55 prior to the formation of the metal plating, it is effective in that the flatness

of the transfer surface will not be compromised by the formation of the metal plating.

Next, the transfer sheet 61 is removed. The removal of the transfer sheet 61 is comprised of a step of separating and removing the metal base material 62 from the dissolvee metal layer 64 (Fig. 10B), and a step of dissolving and removing the dissolvee metal layer 64 (Fig. 10C).

Since this step of removing the transfer sheet 61 is performed through a method similar to the method described in the first embodiment above, a description thereof will herein be omitted.

After the removal of the transfer sheet 61 is completed, as shown in Fig. 10D, a step of filling the through-holes 53 of the insulating base material 51 with an electrically conductive material 59 as an electrically conductive material through screen printing or a dispensing method, while covering the surface of the conductor pattern 55, except for parts corresponding to areas where the through-holes 53 are formed, with a solder resist 60 is performed.

Thus, a device-incorporated substrate 50' of the present embodiment is produced.

According to the present embodiment, advantages similar to those of the first embodiment described above can be obtained.

In particular, according to the present embodiment, since the conductor pattern 55 can be bonded to the insulating base material 51 with high adhesion strength, it is possible to obtain the device-incorporated substrate 50' that is superior in durability.

In addition, in cases where a metal plating is formed in the chip mounting area of the conductor pattern 55, since short circuiting within the pattern can be prevented, it is possible to

accommodate the mounting of semiconductor chips having a narrow pad pitch.

(Fourth Embodiment)

Next, Fig. 11A through Fig. 11F show the fourth embodiment of the present invention. In the present embodiment, a method of manufacturing a device-incorporated substrate related to the present invention will be described. It is to be noted that, in the drawings, the same reference numerals are given to parts that have correspondence in the first embodiment described above, and detailed descriptions thereof will be omitted.

In the present embodiment, a plating resist 72A (Fig. 11B) for electroplating formed when depositing a conductor pattern 55 on the surface of a transfer sheet 61, shown in Fig. 11A, on the side of a dissolvee metal layer 64 is configured as the insulating film 87 for flattening described in the third embodiment above.

The plating resist 72A is such that, at the time of forming the conductor pattern 55, the gaps in the conductor pattern 55 are filled as shown in Fig. 11C.

Therefore, after the conductor pattern 55 is formed, it becomes possible to adhere it onto an insulating base material 51, as shown in Fig. 11D, without having to separately form an insulating film for flattening, and thus, advantages similar to those of the third embodiment described above can be obtained.

In addition, by using a material having adhesiveness for the plating resist 72A, it is possible to adhere the conductor pattern 55 onto the insulating base material 51 with higher bonding strength.

In addition, in this case, if the wiring density of the conductor pattern 55 is relatively low, it is possible to do without an adhesive 54 on the insulating base material 51.

Since the chip mounting process (Fig. 11E) and the process of removing the transfer sheet (Fig. 11F) after adhering the conductor pattern 55 are similar to those of the first embodiment described above, descriptions thereof will herein be omitted.

Hereinabove, embodiments of the present invention have been described, however, the present invention is by no means limited thereto, and various modifications are possible based on the technical spirit of the present invention.

For example, in the respective embodiments above, the transfer sheets 61 and 91 were configured, as shown in Fig. 5A, with the electrically conductive adhesive resin layer 63 lying between the metal base materials 62 and 92 and the dissolvee metal layers 64 and 94 so as to make the metal base materials 62 and 92 and the dissolvee metal layers 64 and 94 separable from each other, but the configuration of the transfer sheets 61 and 91 are not limited thereto, and so long as the configuration allows for the separation of the metal base material and the dissolvee metal layer from each other, any configuration may be adopted.

For example, a transfer sheet 101, whose sectional structure is shown in Fig. 5B, is configured with an intermediate layer 103 of chromium plating lying between a metal base material 102 of copper and a dissolvee metal layer 104 of nickel plating, and in such a manner that the dissolvee metal layer (Ni) 104 and the intermediate layer (Cr) 103 are separated at the interface making use of the plating stress difference. In the step of melting and removing the dissolvee metal layer (Ni) 104 after the metal base material 102 and the intermediate layer 103 have been removed, if the conductor pattern to be transferred is copper, a sulfated hydrogen peroxide etching solution, for example, may be used.

In addition, in Fig. 5B, if the intermediate layer 103 and the dissolvee metal layer 104 are formed of chromium plating and nickel-cobalt alloy plating, respectively, each of the layers 103 and 104 can be easily separated at the interface thereof. In this case, in the step of dissolving and removing the dissolvee metal layer (Ni/Co) 104, if the conductor pattern to be transferred is copper, a soft-etching agent with a sulfated hydrogen peroxide solution base, for example, may be used.

In addition, in each of the embodiment above, examples in which the removal of the transfer sheets 61 and 91 are comprised of the step of separating and removing the metal base materials 62 and 92, and the step of dissolving and removing the dissolvee metal layer 64 and 94 were described, however, instead, the transfer sheet as a whole may be dissolved and removed. In this case, the transfer sheet may be comprised of similar metals, or it may be comprised of a layered body of dissimilar metals. In particular, in the latter case, each metal layer may be selectively etched using different etching solutions.

For example, Fig. 5C shows the configuration of a transfer sheet 111 comprised of first and second metal layers 112 and 114 that are different from each other. Here, assuming the first metal layer 112 is copper and that the second metal layer 114 is nickel, by using an alkaline etchant, it is possible to etch just the first metal layer (Cu) 112. Similarly, if the first metal layer 112 is copper and the second metal layer 114 is aluminum, by using a warm sulfuric acid solution as an etching solution, it is possible to etch just the first metal layer (Cu) 112. Other combination examples for the first and second metal layers 112 and 114 include nickel and gold, copper and chromium, and the like.

In addition, these combination examples of dissimilar metals can also be applied as combination examples between the

metal constituting the dissolvee metal layer (64, 94) and the metal constituting the conductor pattern (55, 85).

Further, the transfer sheet may be comprised of two layers, the metal base layer and the dissolvee metal layer, and each of these layers may be separated by way of the difference in the thermal expansion coefficient between each layer. Alternatively, as in a transfer sheet 121 shown in Fig. 5D, a heat foaming layer 123 may be placed between a metal base layer 122 and a dissolvee metal layer 124, and the metal base layer 122 and the dissolvee metal layer 124 may be separated by foaming the heat foaming layer 123 through a process of heating it to a predetermined temperature.

As described above, according to a method for manufacturing a device-incorporated substrate and a method for manufacturing a printed circuit board of the present invention, since a metallic sheet is used for the transfer sheet, it is possible to form a fine-pitch conductor pattern with high precision, and it is also possible to transfer the formed conductor pattern to an insulating layer while ensuring dimensional stability. In addition, because the removal of the transfer sheet is ultimately carried out by dissolving and removing the transfer sheet, it is possible to ensure a proper transfer process for the conductor pattern.

In addition, because the transfer sheet includes a metal base material and a dissolvee metal layer that is layered so as to be separable with respect to the metal base material, and because the removal of this transfer sheet is comprised of a step of separating and removing the metal base material from the dissolvee metal layer and a step of dissolving and removing the dissolvee metal layer, the cost, in terms of time, required for the

step of removing the transfer sheet is reduced, and an improvement in productivity can be expected.

Further, according to a device-incorporated substrate and a printed circuit board of the present invention, since the conductor pattern formed on the insulating layer is comprised of an electroplated layer, the conductor pattern can be made finer in pitch, and packaging density can be improved.